The Classic Cox or the Counterfactual Potential Outcome? A Simulation Study of Treatment Effects in Survival Analysis

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Abstract

This thesis explores and compares the Cox regression model, a classical epidemiological aaproach, and the modeling of potential outcomes using causal survival analysis (counterfactual approach). Both frameworks are used to estimate treatment effects in survival time analysis.

We present a common theoretical foundation for survival analysis and detail the methods and assumptions of the classical Cox model and the counterfactual framework. We compare and analyze the strengths and weaknesses of each procedure through a simulated observational study.

A core difference between the two is the assumption of proportional hazards: the Cox regression model requires it, whereas counterfactual models do not.

We apply the comparison to the Cox regression model, a discrete-time inverse probability-weighted pooled logistic regression model for a marginal treatment effect, and a standardized conditional pooled logistic regression outcome model. We draw results based on the estimated treatment effects, given a conditional or marginal estimate target, and compare to a hybrid between the two approaches, an inverse probability-weighted Cox model.

Finally, a visual comparison is drawn based on an estimated treatment effect derived from the chosen model parameters, regardless of the approach. Results show that each approach outperforms the other in its own setup for estimating a conditional or a marginal treatment effect.

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